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Lee

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(54) **MOTOR**

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7/04; H02K 1/22

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,634,530 B2 * 4/2017 Klein H02K 29/03
2015/0108867 A1 4/2015 Nakagawa et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 103779993 5/2014
JP 2003-032927 1/2003

(Continued)

OTHER PUBLICATIONS

International Search Report dated Dec. 13, 2019 issued in Appli-
cation No. PCT/KR2019/011645.

(Continued)

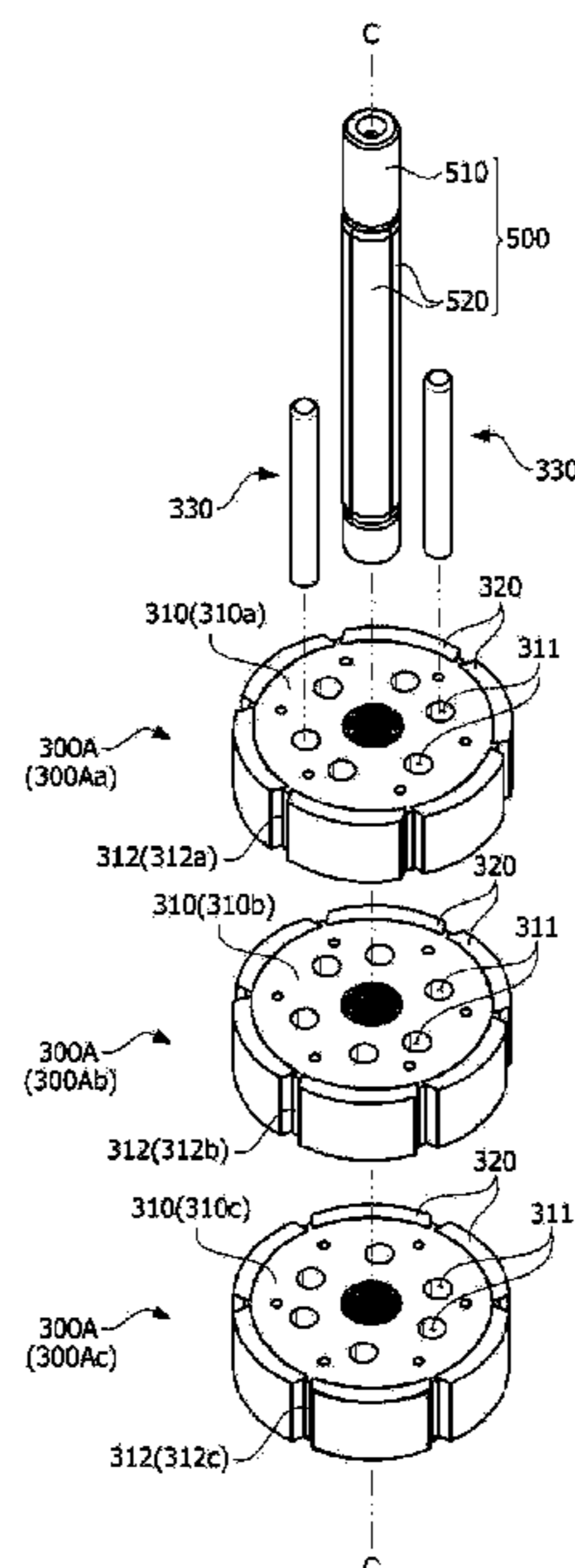
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(57) **ABSTRACT**

An embodiment relates to a motor comprising: a shaft; a rotor connected to the shaft; and a stator disposed outside the rotor, wherein the rotor includes N rotor cores, and the number of holes formed through each of the N rotor cores is at least 2N. Accordingly, the motor allows the rotor to have a skew angle by using the multiple holes formed through the rotor cores.

19 Claims, 10 Drawing Sheets



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(56) **References Cited**

U.S. PATENT DOCUMENTS

2016/0294251 A1* 10/2016 Fukasaku F04C 23/02
2018/0097413 A1* 4/2018 Sun H02K 1/28

FOREIGN PATENT DOCUMENTS

JP 2009-225519 10/2009
JP 2010-233291 10/2010
JP 2018-088748 6/2018
KR 10-2015-0051566 5/2015
KR 10-2017-0110470 10/2017

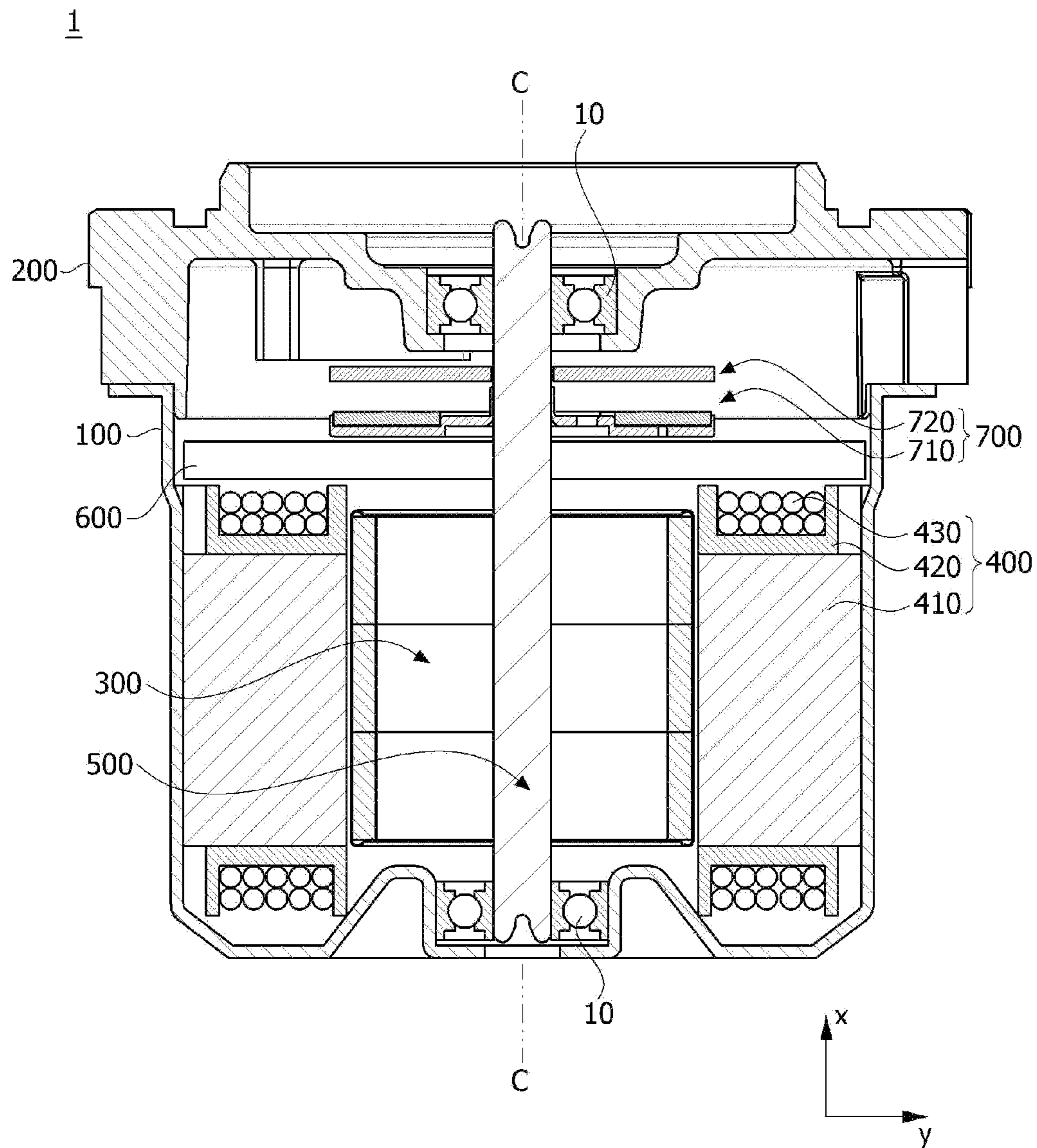
OTHER PUBLICATIONS

European Search Report dated May 12, 2022 issued in Application No. 19863436.2.

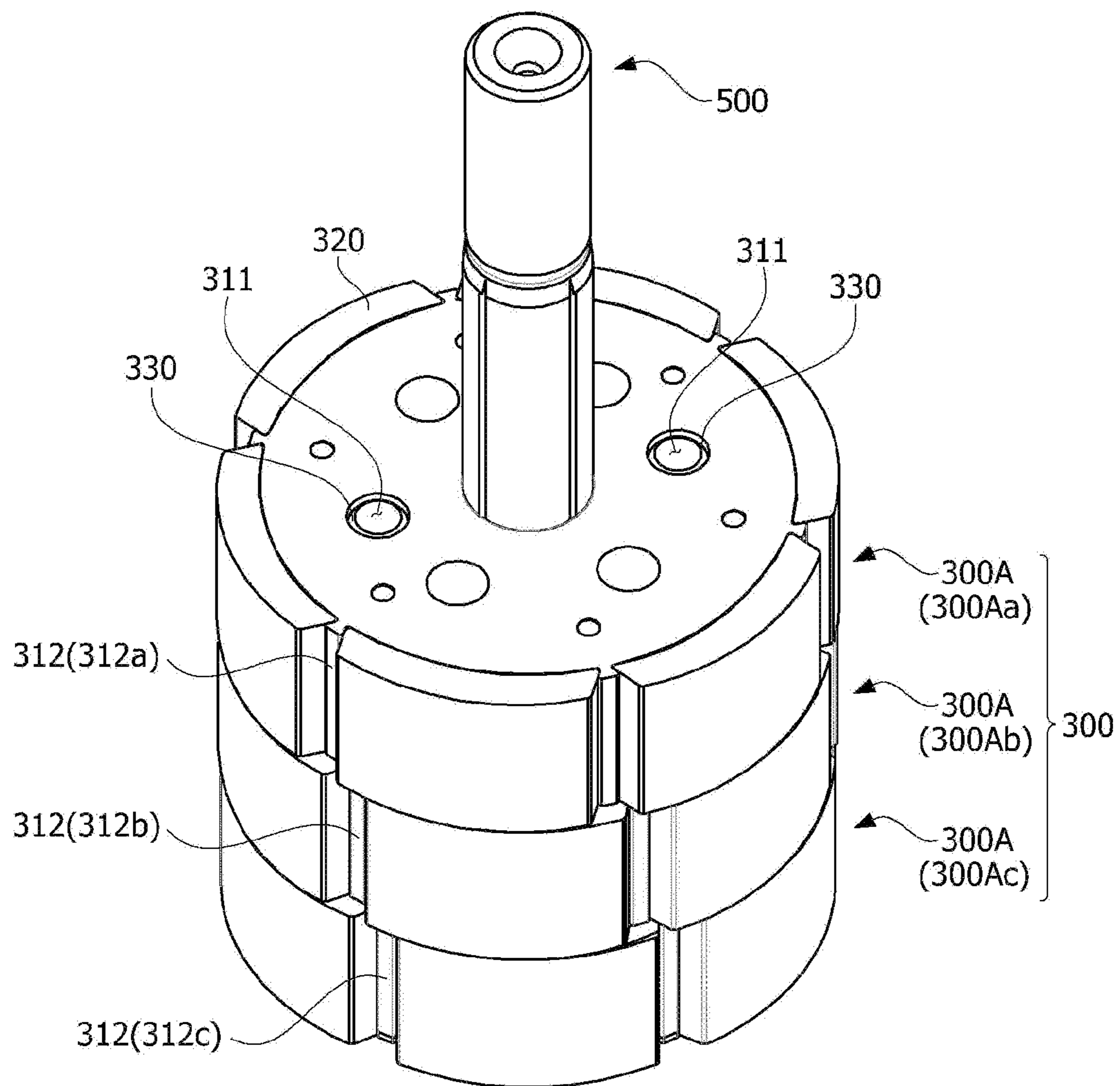
Korean Office Action dated Sep. 13, 2023 issued in Application No. 10-2018-0111769.

* cited by examiner

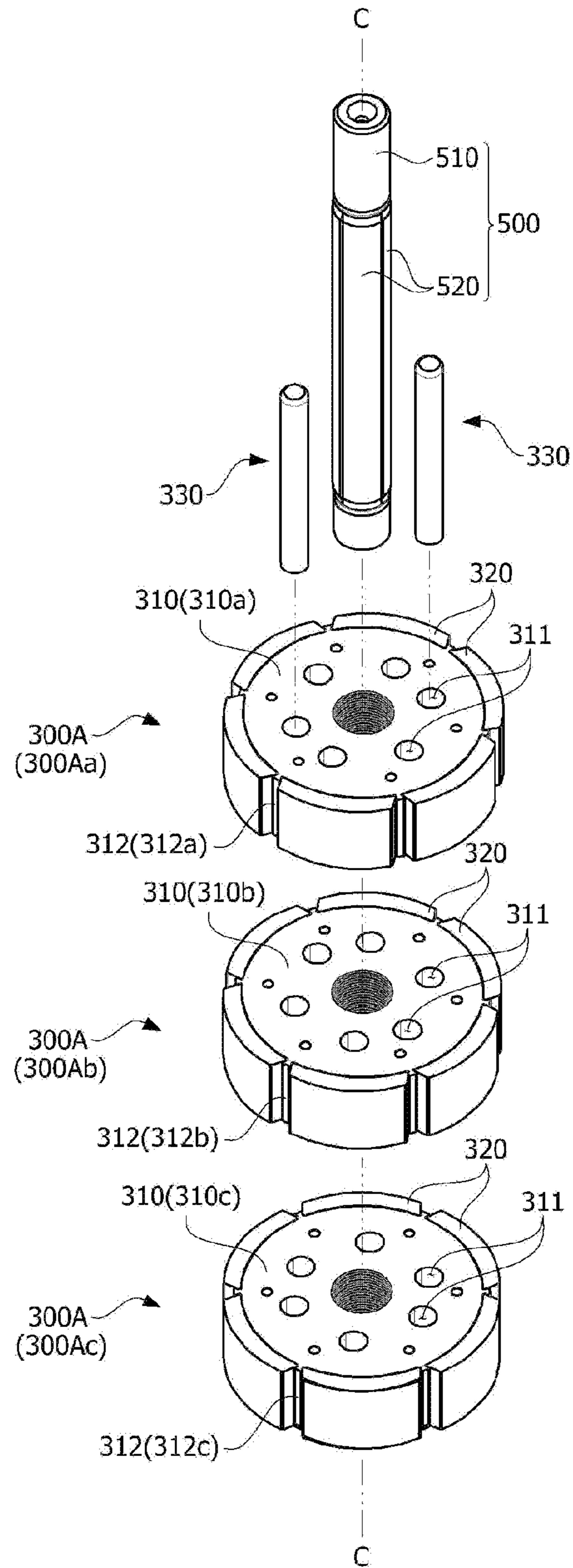
[FIG. 1]



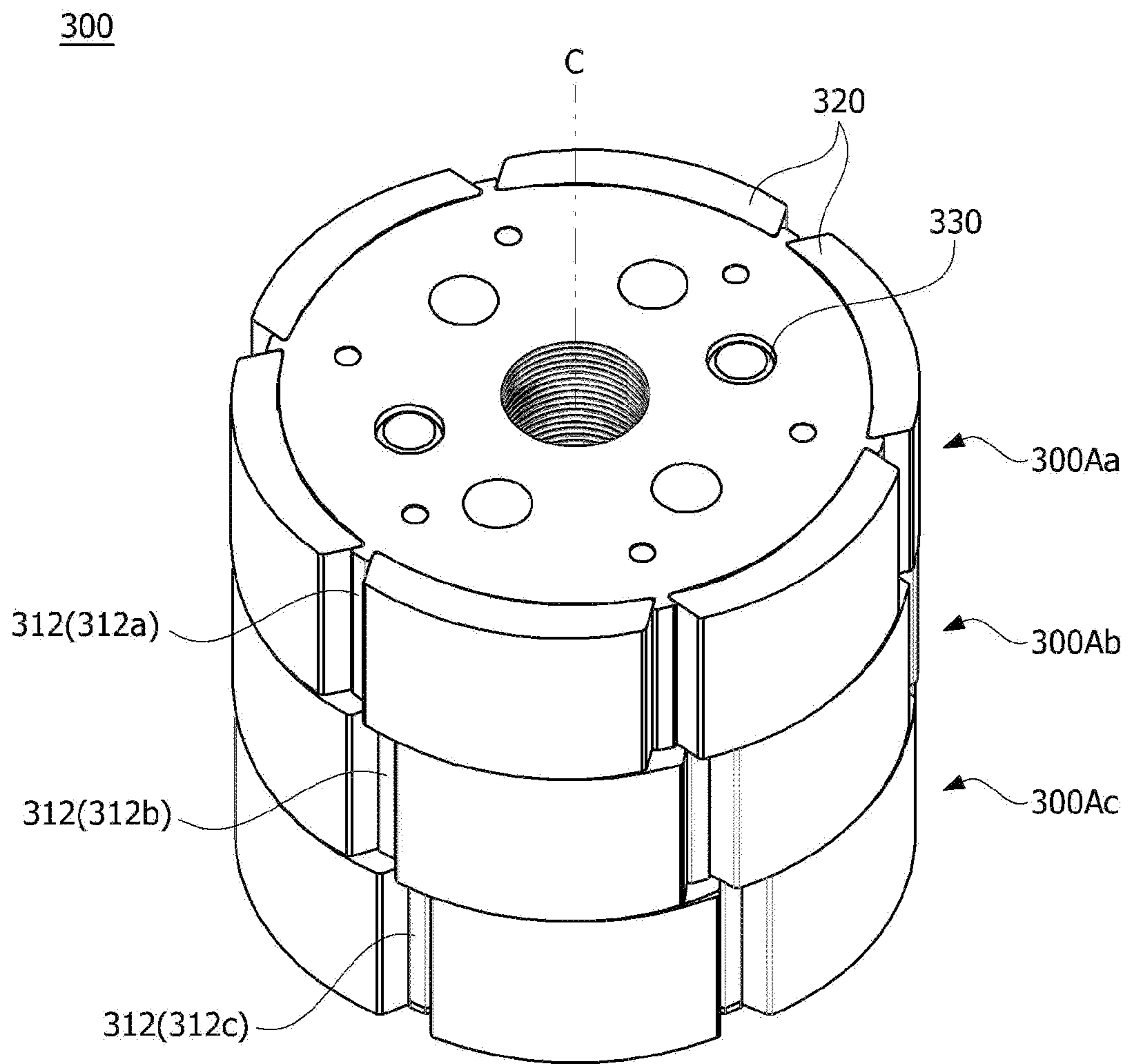
[FIG. 2]



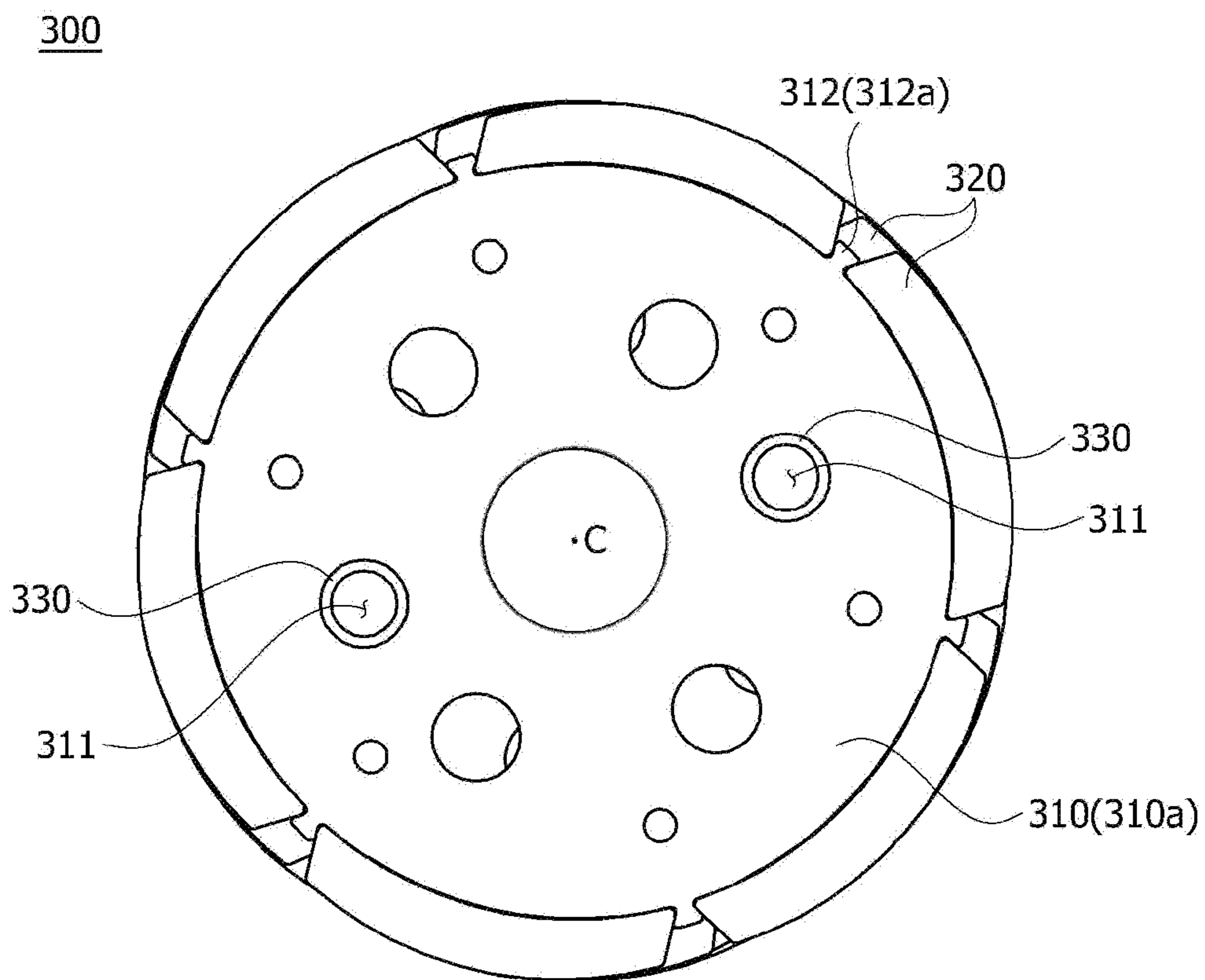
[FIG. 3]



[FIG. 4]

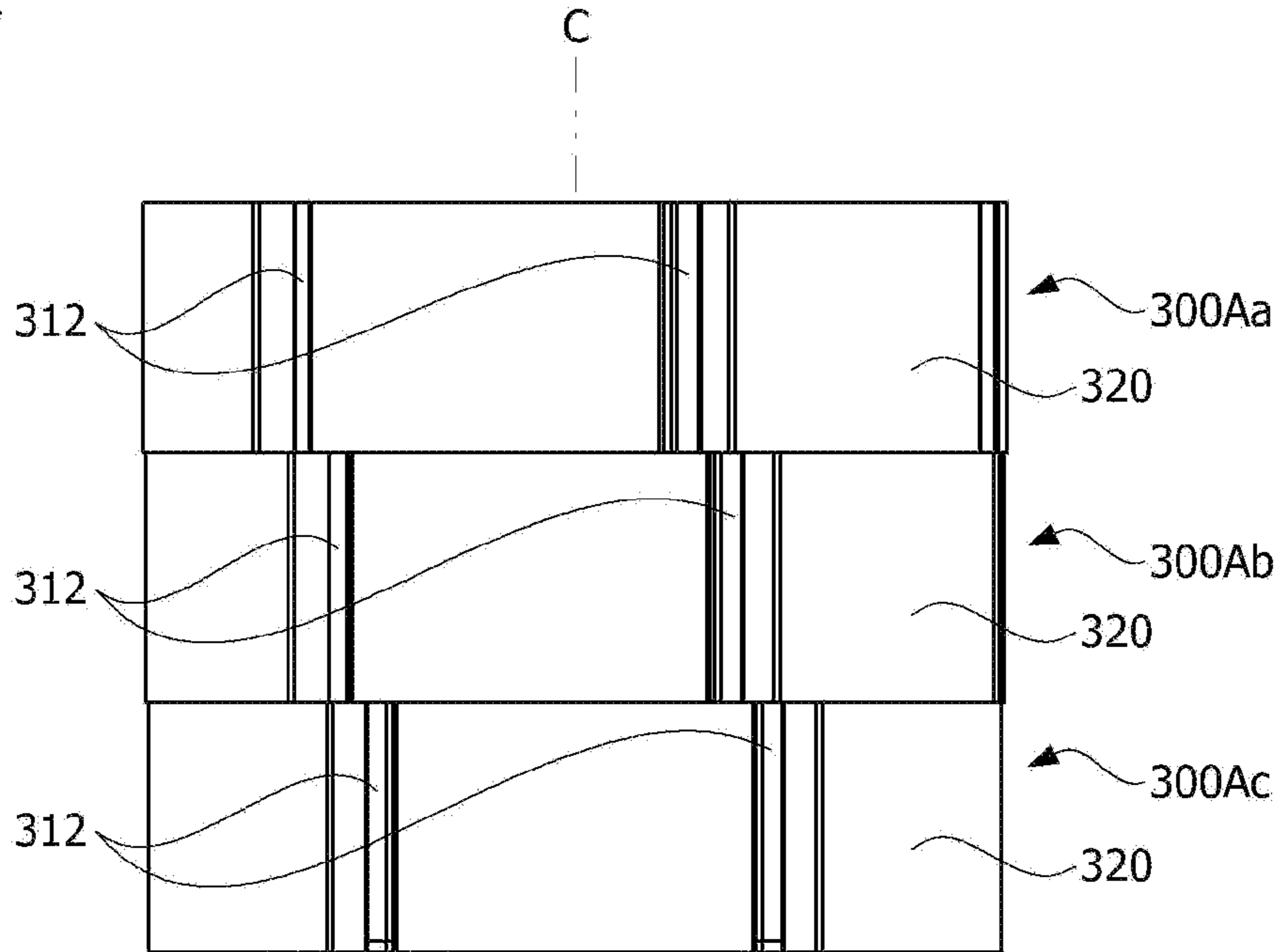


[FIG. 5]



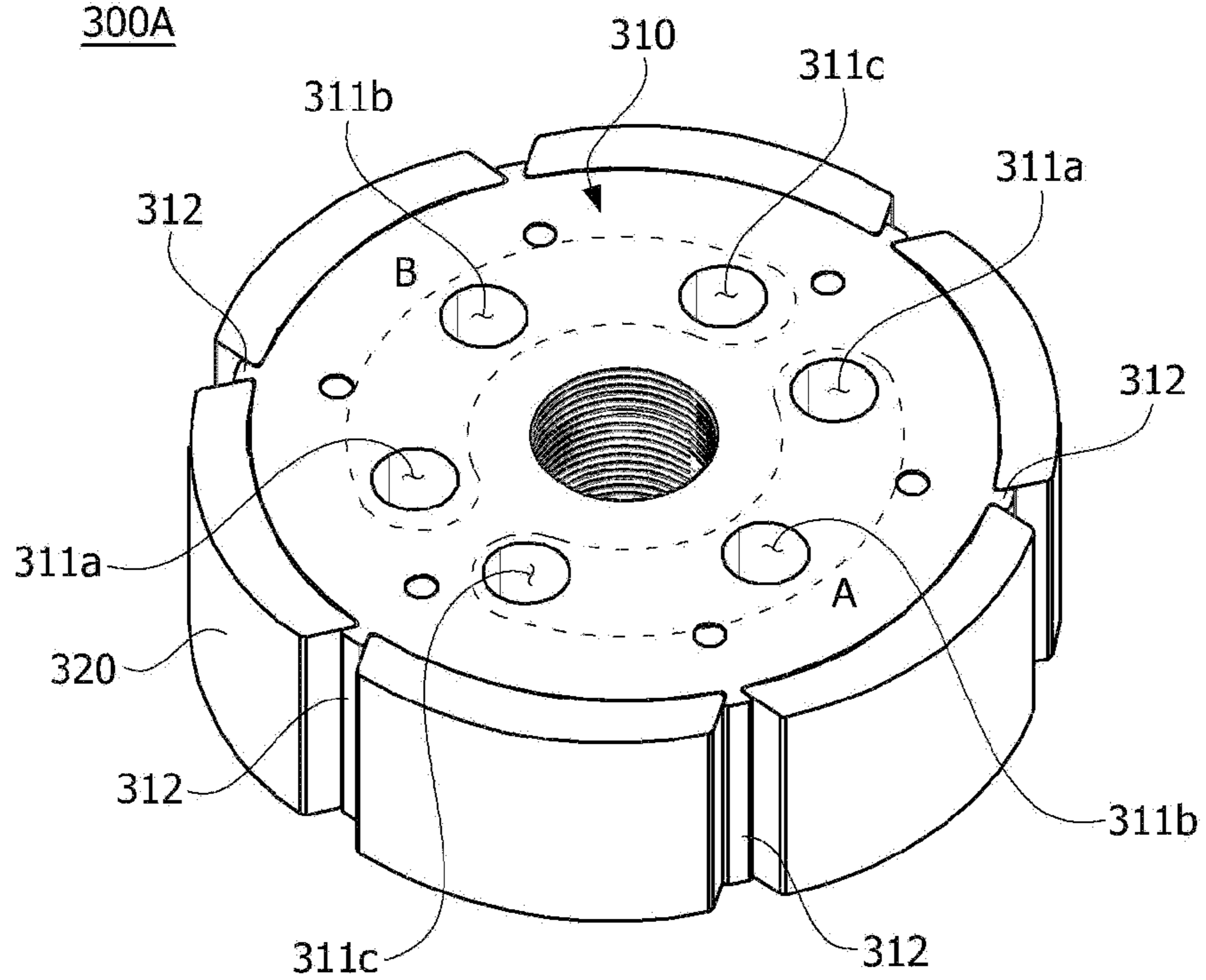
[FIG. 6]

300



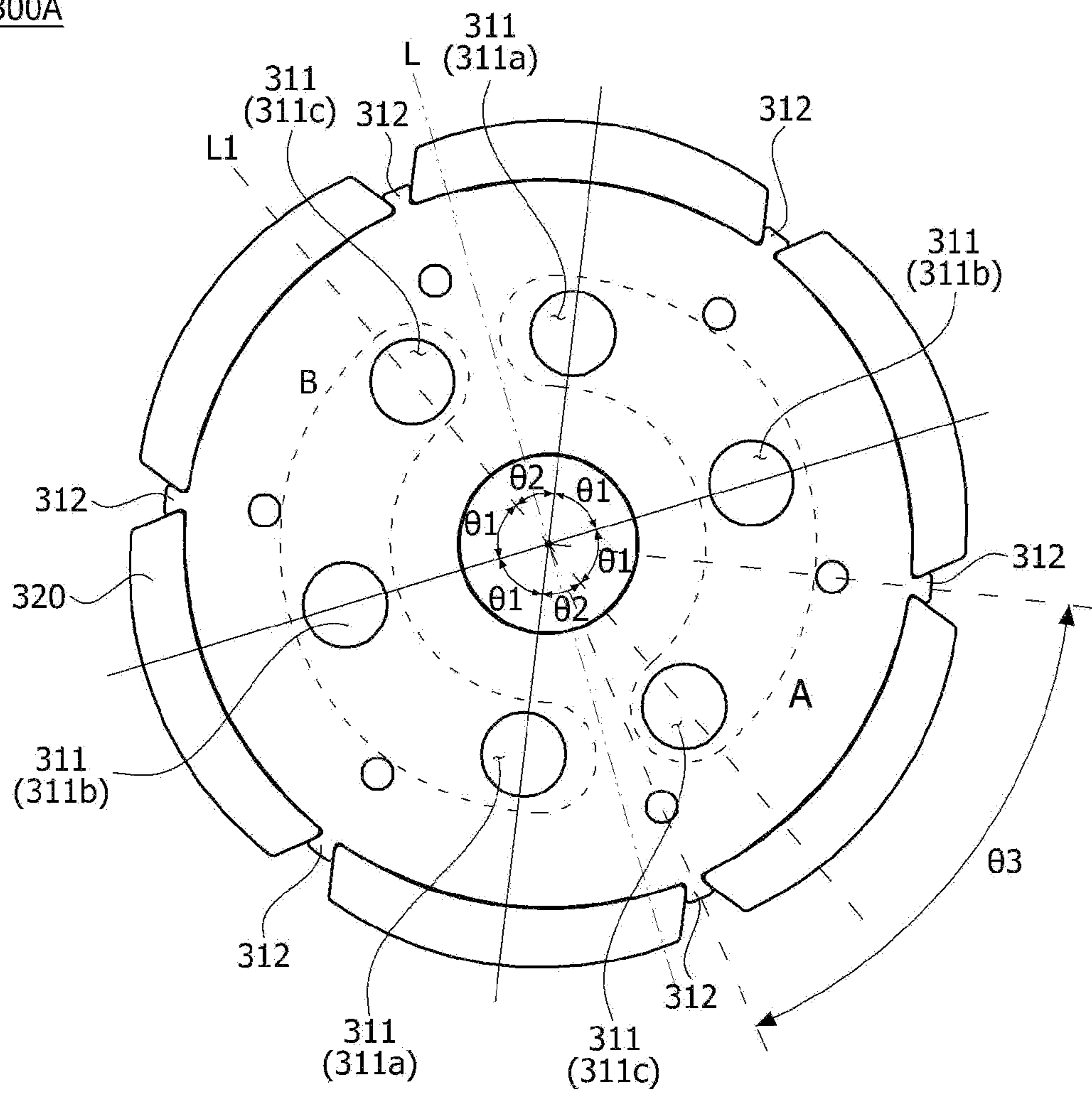
[FIG. 7]

300A

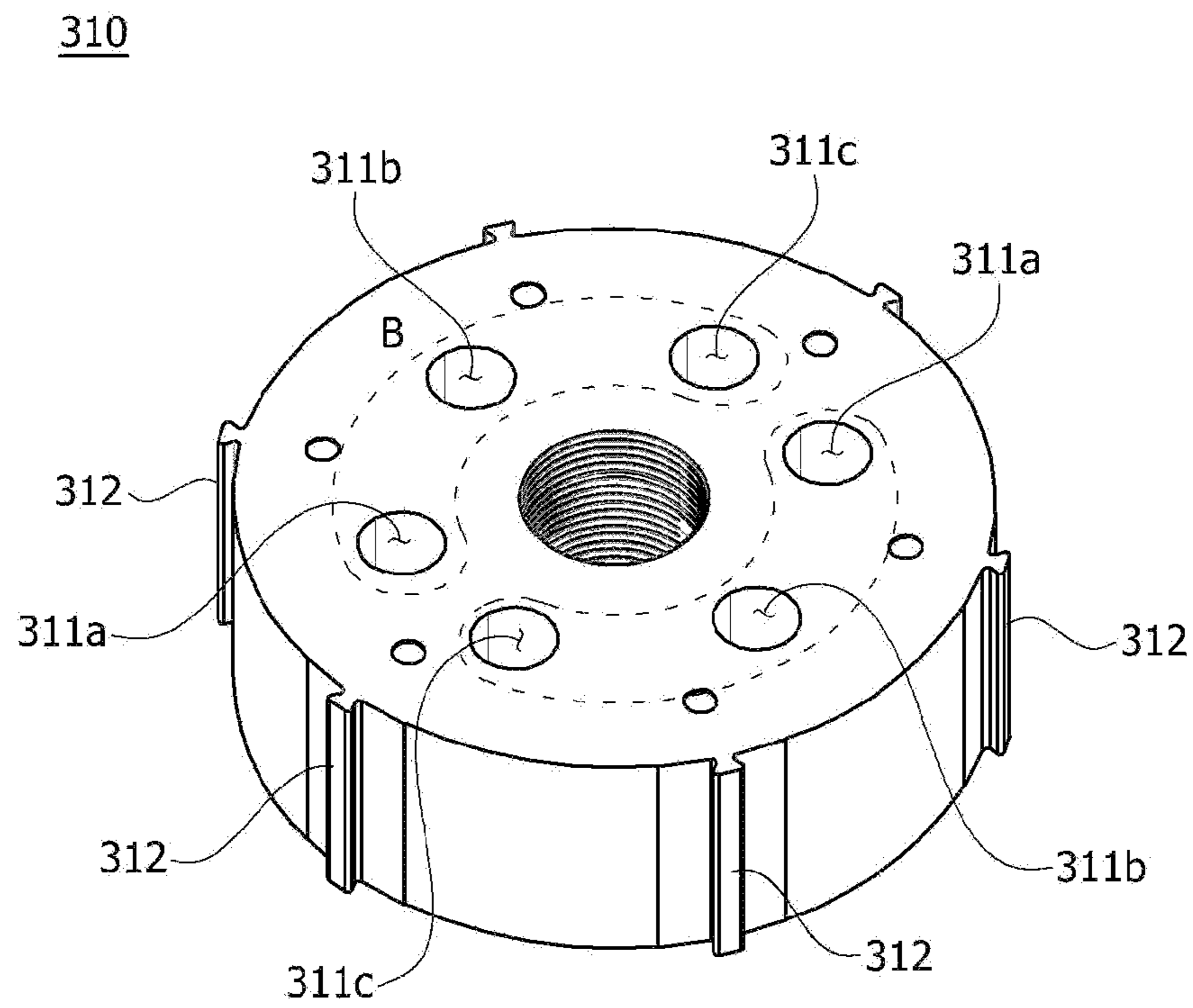


[FIG. 8]

300A

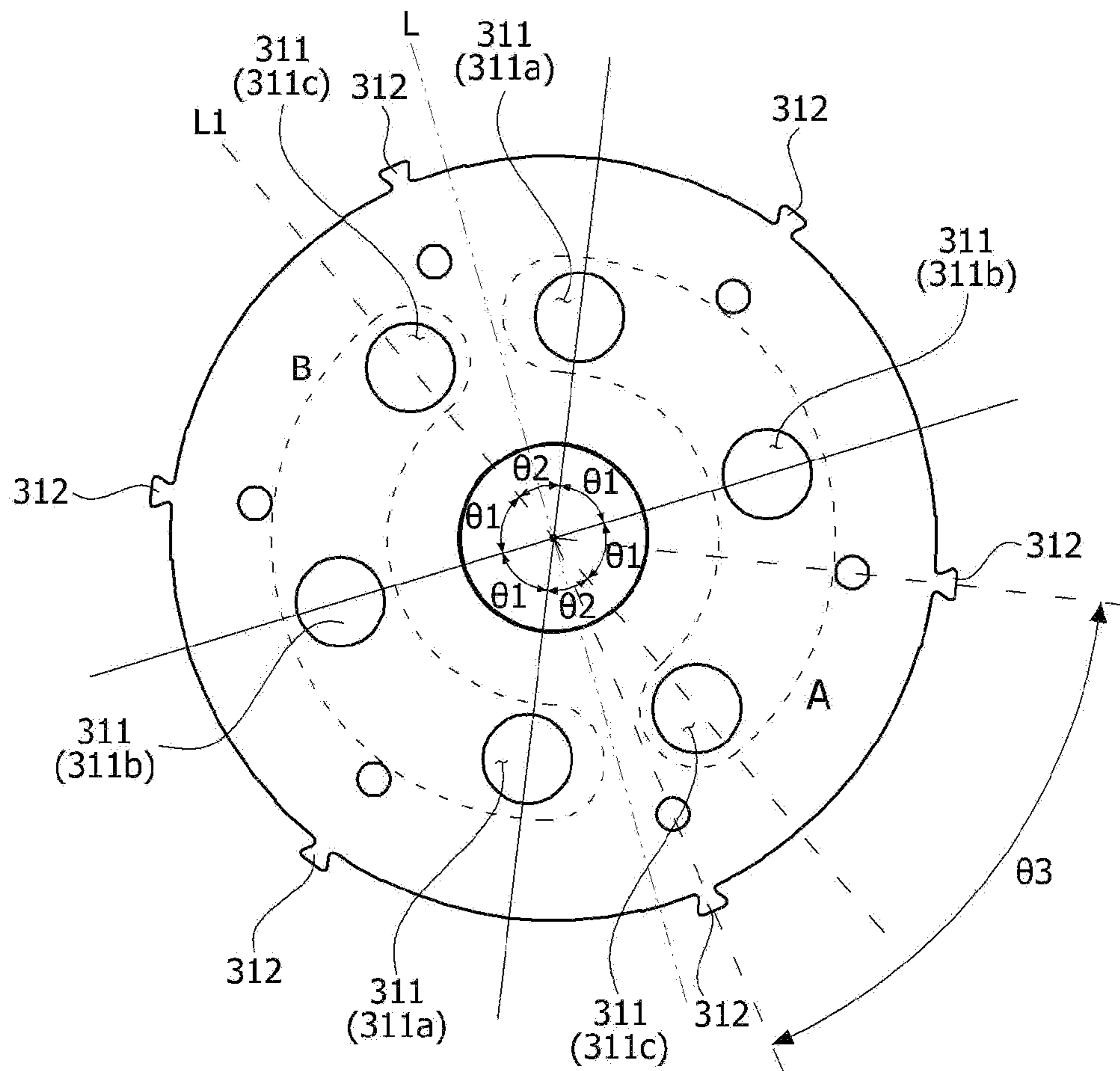


[FIG. 9]

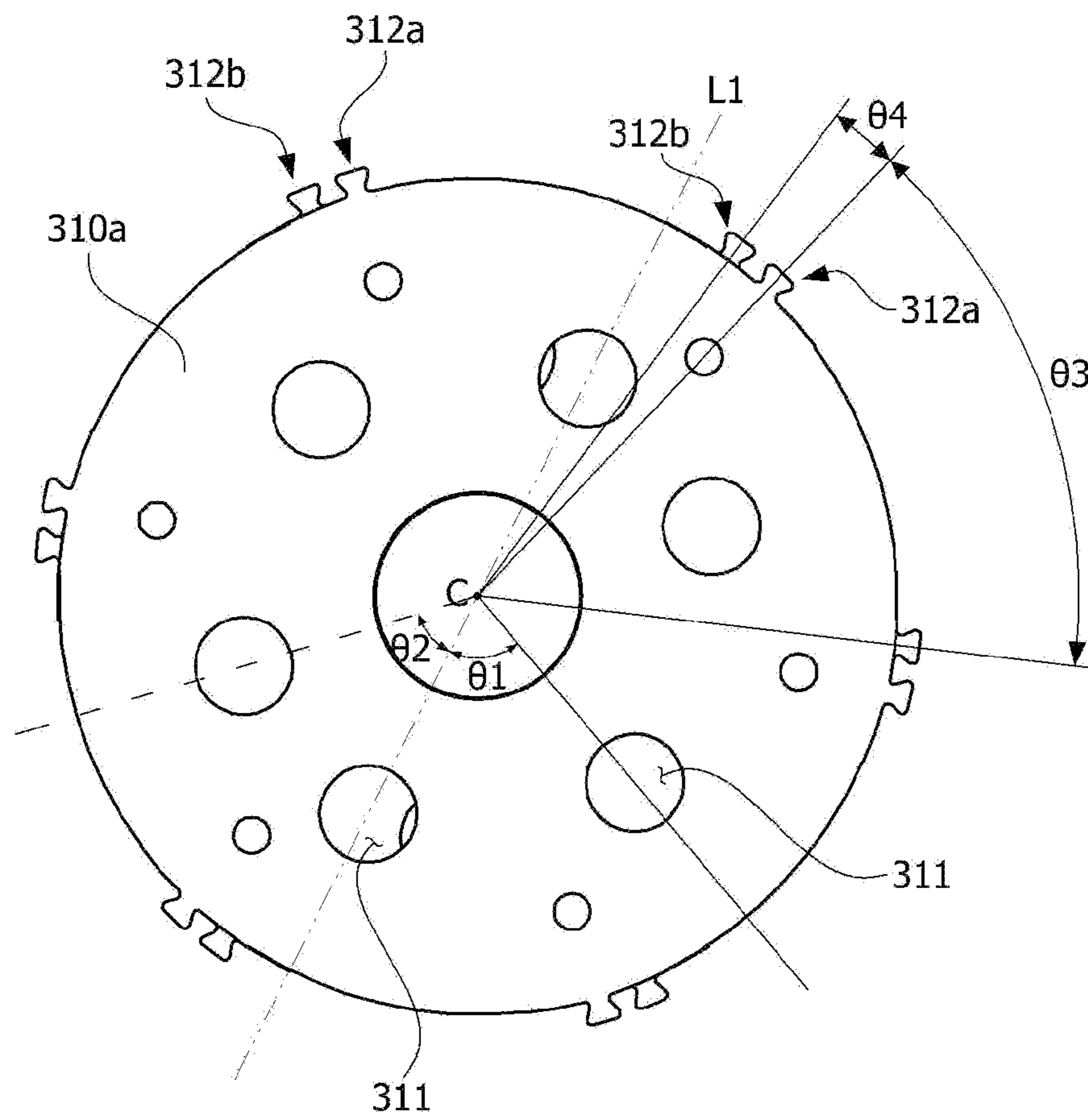


[FIG. 10]

310



[FIG. 11]



1**MOTOR**CROSS-REFERENCE TO RELATED PATENT
APPLICATIONS

This application is a U.S. National Stage Application under 35 U.S.C. § 371 of PCT Application No. PCT/KR2019/011645, filed Sep. 9, 2019, which claims priority to Korean Patent Application No. 10-2018-0111769, filed Sep. 18, 2018, whose entire disclosures are hereby incorporated by reference.

TECHNICAL FIELD

The present invention relates to a motor.

BACKGROUND ART

Motors are apparatuses configured to convert electrical energy to mechanical energy to obtain rotational forces and are widely used for vehicles, home appliances, industrial machines, and the like.

A motor may include a housing, a shaft, a stator disposed in the housing, a rotor installed on an outer circumferential surface of the shaft, and the like. In this case, an electrical interaction is induced between the stator and the rotor so that the rotor rotates. In addition, the shaft also rotates according to the rotation of the rotor.

Particularly, the motor may be used in an apparatus for securing steering stability of a vehicle. For example, the motor may be used as a motor in an electronic power steering (EPS) system or the like for a vehicle.

The rotor may be formed by stacking a plurality of unit rotors.

In this case, the rotor is formed so that a skew angle is applied between unit rotors to improve a cogging torque.

However, when the shaft is press-fitted to the rotor, a problem occurs in that the skew angle is distorted. Accordingly, a cogging torque of the motor is increased and thus there is a problem in that quality of the motor is degraded.

Technical Problem

The present invention is directed to providing a motor in which a skew angle is formed in a rotor using a plurality of holes formed in unit rotor cores.

In addition, the present invention is directed to providing a motor in which a skew angle formed in a rotor is prevented from being distorted by using a pin disposed in a hole.

Objectives to be solved by the present invention are not limited to the above-described objectives, and other objectives which are not described above will be clearly understood by those skilled in the art from the following specification.

Technical Solution

One aspect of the present invention provides a motor including a shaft, a rotor coupled to the shaft, and a stator disposed outside the rotor, wherein the rotor includes N rotor cores, and the number of holes, each of which is formed in one of the N rotor cores, is at least 2N.

The 2N holes may include a first group having N holes for arranging the rotor cores and a second group having N holes for balancing rotation of the rotor cores, and first angles (θ_1) formed between the N holes of the first group may be the same.

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A second angle (θ_2) formed by a first hole of the first group and the hole, which is closest to the first hole, of the second group may be different from the first angle (θ_1) of the first group. In this case, the first hole of the first group may be a reference hole for arranging the rotor cores.

The hole of the first group and the hole of the second group may be symmetrically disposed based on a center of the rotor core.

Each of the N rotor cores may include a plurality of guide protrusions formed on an outer circumferential surface of the rotor core, and the guide protrusions of the N rotor cores may not overlap in a vertical direction.

Each of the N rotor cores may include a first rotor core and a second rotor core, each of which includes a plurality of guide protrusions,

the first angle may be greater than a third angle (θ_3) formed by two guide protrusions, which are disposed adjacent to each other, of the plurality of guide protrusions formed on the first rotor core.

The first angle (θ_1) may be the sum of the third angle (θ_3) and an angle (θ_4) formed by one of the guide protrusions of the first rotor core and the guide protrusion, which is closest to the one of the guide protrusions, of the second rotor core.

Another aspect of the present invention provides a motor including a shaft, a rotor coupled to the shaft, and a stator disposed outside the rotor, wherein the rotor includes a first rotor core, a second rotor core, and a third rotor core, each of which includes M holes spaced apart from each other, the M holes include a first hole which is a reference hole, a second hole adjacent to the first hole, and a third hole adjacent to the second hole, and the first hole of the first rotor core is disposed to overlap the second hole of the second rotor core and the third hole of the third rotor core in a vertical direction.

The rotor may further include a pin disposed to pass through the first hole of the first rotor core, the second hole of the second rotor core, and the third hole of the third rotor core which are disposed to overlap in the vertical direction.

Still another aspect of the present invention provides a motor including a shaft, a rotor coupled to the shaft, and a stator disposed outside the rotor, wherein the rotor includes a first rotor core and a second rotor core, each of which includes a plurality of holes spaced apart from each other and guide protrusions, and two holes, which are adjacent to each other, of the holes of the first rotor core form a first angle (θ_1) which is the same as a sum of an angle (θ_3) formed by two guide protrusions, which are adjacent to each other, of the guide protrusions of the first rotor core and an angle (θ_4) formed by the guide protrusion of the first rotor core and the guide protrusion, which is closest to the guide protrusion of the first rotor core in a circumferential direction, of the second rotor core around a center of the first rotor core.

Yet another aspect of the present invention provides a motor including a shaft, a rotor coupled to the shaft, and a stator disposed outside the rotor, wherein the rotor includes a plurality of rotor cores and a plurality of magnets disposed on an outer circumferential surface of each of the rotor cores, each of the rotor cores includes first holes, second holes, and third holes, two of the first holes, two of the second holes, and two of the third holes are disposed mutually opposite to each other based on a center (C) of the shaft, a first angle (θ_1) formed by one of the first holes and the second hole is the same as an angle formed by the second hole and the third hole around the center (C), the plurality of rotor cores include a first rotor core, a third rotor core, and a second rotor core disposed between the first rotor core and

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the third rotor core, and the first hole of the first rotor core, the second hole of the second rotor core, and the third hole of the third rotor core overlap in a shaft direction.

When the number of the magnets is six, a second angle (θ_2) formed by the one of the first holes and the third hole which is disposed adjacent to the one of the first holes around the center (C) may be smaller than the first angle (θ_1).

The first angle (θ_1) may be 66.67° .

When the number of the magnets is eight, a second angle (θ_2) formed by the one of the first holes and the third hole which is disposed adjacent to the one of the first holes around the center (C) may be greater than the first angle (θ_1).

The first angle θ_1 may be 50° .

The sum of an angle formed by the first hole and the second hole, an angle formed by the second hole and the third hole, and the second angle θ_2 may be 180° .

The first hole and the second hole may be symmetrically disposed based on a virtual line (L1) connecting a center of the third hole and a center (C) of the rotor core.

The rotor may further include a pin disposed to pass through the first hole of the first rotor core, the second hole of the second rotor core, and the third hole of the third rotor core which are disposed to overlap in a vertical direction.

The pin may be provided as two pins.

Advantageous Effects

In a motor according to embodiments, a skew angle can be formed in a rotor using a plurality of holes formed in rotor cores. In this case, the hole can be provided as a reference hole when the plurality of rotor cores are disposed in a shaft direction to form the skew angle.

In addition, a pin disposed in the hole can prevent the skew angle formed in the rotor from being distorted and can guide coupling of the rotor cores to form the skew angle.

Various useful advantages and effects of the embodiments are not limited to the above-described contents and will be more easily understood from descriptions of the specific embodiments.

DESCRIPTION OF DRAWINGS

FIG. 1 is a view illustrating a motor according to an embodiment.

FIG. 2 is a perspective view illustrating coupling of a rotor and a shaft of the motor according to the embodiment.

FIG. 3 is an exploded perspective view illustrating the coupling of the rotor and the shaft of the motor according to the embodiment.

FIG. 4 is a perspective view illustrating the rotor disposed in the motor according to the embodiment.

FIG. 5 is a plan view illustrating the rotor disposed in the motor according to the embodiment.

FIG. 6 is a side view illustrating the rotor disposed in the motor according to the embodiment.

FIG. 7 is a perspective view illustrating a unit rotor of the rotor disposed in the motor according to the embodiment.

FIG. 8 is a plan view illustrating the unit rotor of the rotor disposed in the motor according to the embodiment.

FIG. 9 is a perspective view illustrating a rotor core of the unit rotor disposed in the motor according to the embodiment.

FIG. 10 is a plan view illustrating the rotor core of the unit rotor disposed in the motor according to the embodiment.

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FIG. 11 is a plan view illustrating an arrangement relationship between a first rotor core and a second rotor core of the rotor disposed in the motor according to the embodiment.

MODES OF THE INVENTION

Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

However, the technical spirit of the present invention is not limited to some embodiments which will be described and may be realized using various other embodiments, and at least one component of the embodiments may be selectively coupled, substituted, and used to realize the technical spirit within the range of the technical spirit.

In addition, unless clearly and specifically defined otherwise by context, all terms (including technical and scientific terms) used herein can be interpreted as having customary meanings to those skilled in the art, and meanings of generally used terms, such as those defined in commonly used dictionaries, will be interpreted by considering contextual meanings of the related technology.

In addition, the terms used in the embodiments of the present invention are considered in a descriptive sense and not for limiting the present invention.

In the present specification, unless clearly indicated otherwise by the context, singular forms include the plural forms thereof, and in a case in which "at least one (or one or more) among A, B, and C" is described, this may include at least one combination among all possible combinations of A, B, and C.

In addition, in descriptions of components of the present invention, terms such as "first," "second," "A," "B," "(a)," and "(b)" can be used.

The terms are only to distinguish one element from another element, and an essence, order, and the like of the element are not limited by the terms.

In addition, it should be understood that, when an element is referred to as being "connected or coupled" to another element, such a description may include both of a case in which the element is directly connected or coupled to another element and a case in which the element is connected or coupled to another element with still another element disposed therebetween.

In addition, in a case in which any one element is described as being formed or disposed "on or under" another element, such a description includes both a case in which the two elements are formed or disposed in direct contact with each other and a case in which one or more other elements are interposed between the two elements. In addition, when one element is described as being disposed "on or under" another element, such a description may include a case in which the one element is disposed at an upper side or a lower side with respect to another element.

Hereinafter, example embodiments of the invention will be described in detail with reference to the accompanying drawings. Components that are the same or correspond to each other will be denoted by the same reference numerals regardless of the figure numbers, and redundant descriptions will be omitted.

FIG. 1 is a view illustrating a motor according to an embodiment. In FIG. 1, an x direction may be referred to as a shaft direction, and a y direction may be referred to as a radial direction. In addition, the shaft direction may be

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perpendicular to the radial direction. In this case, the shaft direction may denote a longitudinal direction of the shaft **500**.

Referring to FIG. 1, a motor **1** according to the embodiment may include a housing **100** in which an opening is formed at one side thereof, a cover **200** disposed on the housing **100**, a rotor **300** coupled to a shaft **500**, a stator **400** disposed in the housing **100**, the shaft **500** configured to rotate with the rotor **300**, a busbar **600** disposed above the stator **400**, and a sensor part **700** configured to detect rotation of the rotor **300**. In this case, the rotor **300** may be formed by stacking a plurality of unit rotors **300A** in the shaft direction. In this case, each of the unit rotors **300A** may include a rotor core **310**, in which a plurality of holes are formed, and magnets **320** disposed on the rotor core **310**. In this case, the unit rotor **300A** may be referred to as a puck.

Accordingly, the motor **1** may be manufactured as a skew type motor in which the plurality of rotor cores **310** are disposed to be distorted at a predetermined angle using a plurality of holes in the rotor **300** when the unit rotors **300A** are stacked. In this case, in the motor **1**, a pin **330** coupled to one of the holes may be used to guide an arrangement of the rotor cores **310** to form a preset skew angle and prevent distortion of the rotor cores **310** due to press-fitting of the shaft **500** at the same time.

The motor **1** may be a motor used in an electronic power steering (EPS) system. The EPS system may assist a steering force using a driving force of the motor to secure turning stability and provide a rapid restoring force. Accordingly, a driver of the vehicle can travel safely.

The housing **100** and the cover **200** may form an exterior of the motor **1**. In addition, the housing **100** may be coupled to the cover **200** to form an accommodation space. Accordingly, as illustrated in FIG. 1, the rotor **300**, the stator **400**, the shaft **500**, the busbar **600**, the sensor part **700**, and the like may be disposed in the accommodation space. In this case, the shaft **500** is rotatably disposed in the accommodation space. Accordingly, the motor **1** may further include bearings **10** disposed on an upper portion and a lower portion of the shaft **500**.

The housing **100** may be formed in a cylindrical shape. In addition, the rotor **300**, the stator **400**, and the like may be accommodated in the housing **100**. In this case, the shape or a material of the housing **100** may be variously changed. For example, the housing **100** may be formed of a metal material which firmly withstands even high temperatures.

The cover **200** may be disposed on an open surface of the housing **100**, that is, an upper portion of the housing **100**, to cover an opening of the housing **100**.

FIG. 2 is a perspective view illustrating coupling of the rotor and the shaft of the motor according to the embodiment, and FIG. 3 is an exploded perspective view illustrating the coupling of the rotor and the shaft of the motor according to the embodiment.

Referring to FIGS. 2 and 3, the rotor **300** may be formed by stacking the plurality of unit rotors **300A**. In this case, in the rotor **300**, the pin **330** may be used to guide stacking of the unit rotors **300A**. For example, in a state in which the plurality of unit rotors **300A** are fitted onto the pin **330** to be stacked, the shaft **500** is press-fitted to the unit rotors **300A** to form a rotor assembly in which the rotor **300** and the shaft **500** are coupled. Accordingly, when the shaft **500** is press-fitted thereto, the pin **330** may prevent the rotor cores **310** from being distorted due to the press-fitting.

FIG. 4 is a perspective view illustrating the rotor disposed in the motor according to the embodiment, FIG. 5 is a plan view illustrating the rotor disposed in the motor according to

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the embodiment, and FIG. 6 is a side view illustrating the rotor disposed in the motor according to the embodiment.

Referring to FIGS. 4 to 6, the rotor **300** may include the plurality of rotor cores **310**, the plurality of magnets **320** disposed on an outer circumferential surface of each of the rotor cores **310**, and the pin **330** coupled to the rotor core **310** to guide the arrangement of the rotor cores **310**. In this case, a plurality of holes **311** may be formed in each of the rotor cores **310**. In addition, the pin **330** may be disposed in one of the holes **311** to guide the arrangement of the rotor cores **310** so that the magnets **320** are installed to form the preset skew angle.

In this case, since the rotor **300** is formed by stacking the plurality of unit rotors **300A**, the plurality of rotor cores **310** may be disposed in the shaft direction.

In addition, in the rotor **300**, the plurality of unit rotors **300A** may be disposed to be distorted by a predetermined angle to form the skew angle between the unit rotors **300A**.

FIG. 7 is a perspective view illustrating the unit rotor of the rotor disposed in the motor according to the embodiment, FIG. 8 is a plan view illustrating the unit rotor of the rotor disposed in the motor according to the embodiment, FIG. 9 is a perspective view illustrating the rotor core of the unit rotor disposed in the motor according to the embodiment, and FIG. 10 is a plan view illustrating the rotor core of the unit rotor disposed in the motor according to the embodiment.

Referring to FIGS. 7 and 8, the unit rotor **300A** may include the rotor core **310**, in which the plurality of holes **311** are formed, and the plurality of magnets **320** disposed on the outer circumferential surface of the rotor core **310**. For example, the plurality of magnets **320** may be disposed on the outer circumferential surface of the rotor core **310** to be spaced apart from each other at preset intervals in a circumferential direction.

In this case, the rotor core **310** may include a plurality of guide protrusions **312** formed to guide an arrangement of the magnets **320**. In this case, the guide protrusions **312** may be formed to protrude from the outer circumferential surface of the rotor core **310** in the radial direction. Accordingly, a side surface of the magnet **320** may be in contact with the guide protrusion **312**.

In this case, the magnets **320** may be referred to as rotor magnets or drive magnets. In addition, the rotor core **310** may be formed in a form in which a plurality of circular thin steel plates are stacked or a single cylindrical form. In addition, a hole coupled to the shaft **500** may be formed at a center C of the rotor core **310**.

As illustrated in FIGS. 9 and 10, the guide protrusions **312** may be formed to be spaced apart from each other in the circumferential direction. Accordingly, the magnets **320** may be disposed between the guide protrusions **312**. In this case, the number of the guide protrusions **312** is the same as the number of the magnets **320**.

In addition, the guide protrusions **312** of the unit rotors **300A** are disposed to not overlap in the shaft direction. Accordingly, the skew angle may be formed between the plurality of magnets **320** disposed in a vertical direction (shaft direction) in the rotor **300**. However, one regions of the guide protrusions **312** may overlap in the shaft direction, but even in this case, centers of the guide protrusions **312** do not overlap in the shaft direction when viewed from above.

Meanwhile, the rotor **300** may be formed by stacking the plurality of unit rotors **300A**.

Referring to FIGS. 2 and 3, a first unit rotor **300Aa**, a second unit rotor **300Ab**, and a third unit rotor **300Ac** to an Nth unit rotor may be disposed downward from an upper

portion thereof in the shaft direction. Accordingly, a first rotor core **310a**, a second rotor core **310b**, and a third rotor core **310c** to an Nth rotor core are disposed downward to be stacked from the upper portion. In addition, the guide protrusions **312** are formed to protrude from the outer circumferential surface of each of the rotor cores **310**, and thus the guide protrusions **312** of the first rotor core **310a**, the guide protrusions **312** of the second rotor core **310b**, and the guide protrusions **312** of the third rotor core **310c** to the guide protrusions **312** of the Nth rotor core may be respectively referred to as first guide protrusions **312a**, second guide protrusions **312b**, and third guide protrusions **312c** to Nth guide protrusions.

In this case, the rotor **300** may include N rotor cores **310**, and the number of the holes **311** formed in each of the N rotor cores **310** may be at least 2N. That is, the number of the holes **311** formed in each of the rotor cores **310** may be two times the number of the rotor cores **310**.

Since the motor **1**, which is illustrated in FIGS. **2** and **3**, includes the rotor **300** having three unit rotors **300A**, the rotor **300** of the motor **1** will be described with respect to FIGS. **2** and **3**. Accordingly, the motor **1** may include three rotor cores **310**. In addition, six holes **311** may be formed in each of the three rotor cores **310**.

In addition, the 2N holes **311** may include a first group A having N holes **311** for arranging the rotor cores **310** and a second group B having N holes **311** for balancing rotation of the rotor core **310**. For example, when only the first group A having the N holes **311** is provided at one side of the rotor core **310** in the circumferential direction, a rotation balance problem occurs. Accordingly, as the second group B having the N holes **311** is formed to be symmetrical with the first group A, the rotation of the rotor **300** may be balanced.

Accordingly, six holes **311** of the motor **1** may be grouped into two groups each having three holes **311**.

Referring to FIGS. **7** to **10**, the rotor core **310** may include the first group A including the three holes **311** and the second group B including the three holes **311**.

In this case, the plurality of holes **311** forming each of the groups may form first angles θ_1 around the center of the rotor core **310**. For example, two holes **311**, which are adjacent to each other in the circumferential direction, of the N holes **311** of the first group A may form the first angle θ_1 . In addition, two other holes **311**, which are adjacent to each other in the circumferential direction, may also form the first angle θ_1 .

That is, the first angles θ_1 formed between the N holes **311** of the first group A may be the same. In this case, since the holes **311** of the second group B are symmetrically disposed with the holes **311** of the first group A, first angles θ_1 formed between the N holes **311** of the second group B may be the same.

In addition, in the circumferential direction, a first hole **311** of the first group A and the hole **311**, which is closest to the first hole **311**, of the second group B may be disposed to form a second angle θ_2 . In this case, the second angle θ_2 may be different from the first angle θ_1 . In this case, the first hole **311** of the first group A may be one of the holes **311** disposed at both ends of the first group A in the circumferential direction.

Referring to FIG. **10**, the three holes **311** of the first group A may be referred to as a first hole **311a**, a second hole **311b**, and a third hole **311c** sequentially in a clockwise direction. In addition, the three holes **311** of the second group B may also be referred to as a first hole **311a**, a second hole **311b**, and a third hole **311c** sequentially in the clockwise direction.

As illustrated in FIG. **10**, the first hole **311a** of the first group A and the third hole **311c** of the second group B may form the second angle θ_2 around the center C. In addition, the second angle θ_2 is different from the first angle θ_1 .

In this case, the first hole **311a** which is the first hole **311** of the first group A may be provided as a reference hole for arranging the rotor cores **310**. Accordingly, in a state in which the pin **330** is coupled to the first hole **311a** of the first rotor core **310a**, the pin **330** may be sequentially coupled to the second hole **311b** of the second rotor core **310b** and the third hole **311c** of the third rotor core **310c**.

In this case, the holes **311** are divided and described as the first hole **311a**, the second hole **311b**, and the third hole **311c** but are not necessarily limited thereto. For example, the holes **311** may be referred to as a first hole **311a**, a second hole **311b**, and a third hole **311c** sequentially in the counterclockwise direction.

In addition, the holes **311** of the first group A and the holes **311** of the second group B may be symmetrically disposed based on the center C of the rotor core **310**.

For example, the holes **311** of the first group A and the holes **311** of the second group B may be disposed to be rotationally symmetrical based on the center C. In addition, when viewed from above, the holes **311** of the first group A and the holes **311** of the second group B may be symmetrically disposed based on a virtual line L passing through, in the radial direction, a center between the first hole **311a** which is the first hole **311** of the first group A and the third hole **311c** of the second group B in the circumferential direction. In this case, the center C of the rotor core **310** may be disposed on the line L.

In addition, the N rotor cores **310** may include the first rotor core **310a** and the second rotor core **310b**, each of which includes the plurality of guide protrusions **312**. In addition, the first angle θ_1 may be greater than a third angle θ_3 formed by two guide protrusions **312**, which are disposed adjacent to each other, of the plurality of guide protrusions **312** formed on the first rotor core **310a**. In this case, the plurality of guide protrusions **312** of the second rotor core **310b** may also form the third angle θ_3 . In addition, the plurality of guide protrusions **312** of the third rotor core **310c** may also form the third angle θ_3 .

FIG. **11** is a plan view illustrating an arrangement relationship between the first rotor core and the second rotor core of the rotor disposed in the motor according to the embodiment.

Referring to FIG. **11**, the first guide protrusion **312a** of the first rotor core **310a** and the second guide protrusion **312b** of the second rotor core **310b** may form a predetermined angle θ_4 around the center C. In this case, the angle θ_4 may be referred to as a fourth angle.

In addition, the first angle θ_1 may be the same as the sum of the third angle θ_3 and the angle θ_4 .

That is, around a center C of the first rotor core **310a**, two holes **311**, which are adjacent to each other, of the plurality of holes **311** of the first rotor core **310a** may form the first angle θ_1 which is the same as the sum of the angle θ_3 formed by two guide protrusions **312**, which are adjacent to each other, of the guide protrusions **312** of the first rotor core **310a** and the angle θ_4 formed by the guide protrusion **312** of the first rotor core **310a** and the guide protrusion **312**, which is closest to the guide protrusion **312** of the first rotor core **310a** in the circumferential direction, of the second rotor core **310b**. In this case, two holes **311**, which are adjacent to each other, of the plurality of holes **311** of the first rotor core **310a** are the holes **311** included in the first group A or the second group B.

Accordingly, the first guide protrusion **312a** of the first rotor core **310a** may be disposed to overlap the magnet **320** attached to the second rotor core **310b** in the shaft direction.

Meanwhile, the rotor **300** may include the first rotor core **310a**, the second rotor core **310b**, and the third rotor core **310c**, each of which includes *M* holes **311** disposed to be spaced apart from each other. In this case, the *M* holes **311** may include a first hole **311a** which is a reference hole, a second hole **311b** disposed adjacent to the first hole **311a** in the circumferential direction, and a third hole **311c** disposed adjacent to the second hole **311b** in the circumferential direction. In addition, the first hole **311a** of the first rotor core **310a** may be disposed to overlap the second hole **311b** of the second rotor core **310b** and the third hole **311c** of the third rotor core **310c** in the vertical direction. In this case, in the rotor **300**, since the rotor **300** includes the holes **311** which overlap in two regions, the plurality of rotor cores **310** disposed in the shaft direction may be prevented from being distorted in the circumferential direction using two pins **330**.

Referring to FIG. 5, the pin **330** may be disposed to pass through the first hole **311a** of the first rotor core **310a**, the second hole **311b** of the second rotor core **310b**, and the third hole **311c** of the third rotor core **310c** which are disposed to overlap in the vertical direction.

In this case, since each of the first hole **311a** of the first rotor core **310a**, the second hole **311b** of the second rotor core **310b**, and the third hole **311c** of the third rotor core **310c** is formed in pairs, holes **311** overlap in the two regions. Accordingly, the two pins **330** may be provided.

Since a possibility of movement or distortion in the circumferential direction is present when one pin **330** is disposed, the two pins **330** are used to prevent the plurality of rotor cores **310**, which are disposed in the shaft direction, from being distorted in the circumferential direction in the rotor **300**.

In addition, the rotor **300** may include the plurality of rotor cores **310** and the plurality of magnets **320** disposed on the outer circumferential surface of each of the rotor cores **310**, and each of the rotor cores **310** may include the first holes **311a**, the second holes **311b**, and the third holes **311c**. In this case, two first holes **311a**, two second holes **311b**, and two third holes **311c** may be disposed mutually opposite to each other based on a center *C* of the shaft **500**.

In addition, around the center *C*, an angle formed by one first hole **311a** and the second hole may be the first angle θ_1 which is the same as an angle formed by the second hole and the third hole.

In addition, the plurality of rotor cores **310** may include the first rotor core **310a**, the third rotor core **310c**, and the second rotor core **310b** disposed between the first rotor core **310a** and the third rotor core **310c**. In this case, the first hole **311a** of the first rotor core **310a**, the second hole **311b** of the second rotor core **310b**, and the third hole **311c** of the third rotor core **310c** may overlap in the shaft direction.

In this case, when the number of the magnets **320** is six, the second angle θ_2 formed by the one first hole **311a** and the third hole **311c** disposed adjacent to the first hole **311a** around the center *C* may be smaller than the first angle θ_1 .

In this case, the first angle θ_1 may be 66.67° .

In addition, the sum of the angle formed by the first hole **311a** and the second hole **311b**, the angle formed by the second hole **311b** and the third hole **311c** around the center *C*, and the second angle θ_2 is 180° .

Referring to FIG. 10, when viewed from above, the first hole **311a** and the second hole **311b** may be symmetrically

disposed based on a virtual line *L1* connecting centers of the pair of the third holes **311c** and the center *C* of the rotor core **310**.

In addition, when the number of the magnets **320** is eight, the second angle θ_2 formed by one first hole **311a** and the third hole **311c** disposed adjacent to the one first hole **311a** around the center *C* may be greater than the first angle θ_1 .

In this case, the first angle θ_1 may be 50° .

In addition, the sum of the angle formed by the first hole **311a** and the second hole **311b**, the angle formed by the second hole **311b** and the third hole **311c** around the center *C*, and the second angle θ_2 is 180° .

Referring to FIG. 10, when viewed from above, the first hole **311a** and the second hole **311b** may be symmetrically disposed based on the virtual line *L1* connecting the centers of the pair of the third holes **311c** and the center *C* of the rotor core **310**.

Meanwhile, the rotor **300** may further include a can (not shown) disposed to cover the rotor core **310** to which the magnets **320** are attached.

The can may protect the rotor core and the magnets from external shocks and physical and chemical stimuli while preventing foreign materials from being introduced to the rotor core and magnets.

In addition, the can prevents the magnets **320** from being separated from the rotor core **310**.

The stator **400** may be disposed inside the housing **100**. In this case, the stator **400** may be supported by an inner circumferential surface of the housing **100**. In addition, the stator **400** is disposed outside the rotor **300**. That is, the rotor **300** may be disposed inside the stator **400**.

Referring to FIG. 1, the stator **400** may include a stator core **410**, insulators **420** disposed on the stator core **410**, and coils **430** wound around the insulators **420**.

The coils **430** configured to generate a rotating magnetic field may be wound around the stator core **410**. In this case, the stator core **410** may be formed as one core or a plurality of divided cores that are coupled.

The stator core **410** may be formed in a form in which a plurality of thin steel sheets are stacked on each other but is not necessarily limited thereto. For example, the stator core **410** may be formed as one single product.

The stator core **410** may include a yoke (not shown) having a cylindrical shape and a plurality of teeth (not shown) protruding from the yoke in the radial direction. In addition, the coil **430** may be wound around the tooth.

The insulator **420** insulates the stator core **410** from the coil **430**. Accordingly, the insulator **420** may be disposed between the stator core **410** and the coil **430**.

Accordingly, the coil **430** may be wound around the stator core **410** on which the insulator **420** is disposed.

The shaft **500** may be disposed in the housing **100** to be rotatable by the bearings **10**. In addition, the shaft **500** may rotate in conjunction with rotation of the rotor **300**.

Referring to FIG. 3, the shaft **500** may include a shaft body **510** formed in a cylindrical shape and a plurality of protrusions **520** disposed on an outer circumferential surface of the shaft body **510** to be spaced apart from each other in the circumferential direction.

The shaft **500** may be coupled to the hole formed at the center of the rotor core **310** through a press-fitting method. In this case, due to the protrusions **520**, the shaft **500** may be easily press-fitted to the rotor core **310**.

The busbar **600** may be disposed above the stator **400**.

In addition, the busbar **600** may be electrically connected to the coils **430** of the stator **400**.

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The busbar **600** may include a busbar body (not shown) and a plurality of terminals (not shown) disposed in the busbar body. In this case, the busbar body may be a mold product formed through an injection molding process. In addition, each of the terminals may be electrically connected to the coil **430** of the stator **400**.

The sensor part **700** may detect a magnetic force of a sensing magnet installed to rotate in conjunction with the rotor **300** to check a present position of the rotor **300** so as to detect rotation of the shaft **500**.

The sensor part **700** may include a sensing magnet assembly **710** and a printed circuit board (PCB) **720**.

The sensing magnet assembly **710** is coupled to the shaft **500** to operate in conjunction with the rotor **300** so as to detect the position of the rotor **300**. In this case, the sensing magnet assembly **710** may include sensing magnets and a sensing plate.

The sensing magnets may include main magnets disposed close to a hole forming an inner circumferential surface thereof in the circumferential direction and sub-magnets formed at an edge thereof. The main magnets may be arranged like the drive magnets inserted into the rotor **300** of the motor. The sub-magnets may be divided further than the main magnets so that the sub-magnets may be formed to have poles of which the number is greater than the number of poles of the main magnets. Accordingly, a rotation angle may be divided and measured more precisely, and thus the motor may be driven more smoothly.

The sensing plate may be formed of a metal material having a disc shape. The sensing magnet may be coupled to an upper surface of the sensing plate. In addition, the sensing plate may be coupled to the shaft **500**. In this case, a hole through which the shaft **500** passes is formed in the sensing plate.

A sensor configured to detect a magnetic force of the sensing magnets may be disposed on the PCB **720**. In this case, a Hall integrated circuit (IC) may be provided as the sensor. In addition, the sensor may detect changes in an N-pole and an S-pole of the sensing magnet to generate a sensing signal.

Meanwhile, in the motor **1**, the protrusions **520** of the shaft **500** may be used to determine a direction of a press-fitting force applied to the rotor core **310** in the radial direction. In addition, in the motor **1**, holes and grooves may be formed in the rotor core **310** to be positioned on radii which are the same as radii on which the protrusions **520** are formed so as to reduce a stress which is applied to the magnets **320** due to the press-fitting force.

While the present invention has been described with reference to the exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

[Reference Numerals]

1: MOTOR	100: HOUSING
200: COVER	300: ROTOR
300A: UNIT ROTOR	310: ROTOR CORE
310A: FIRST ROTOR CORE	310B: SECOND ROTOR CORE
310C: THIRD ROTOR CORE	311: HOLE
311A: FIRST HOLE	311B: SECOND HOLE
311C: THIRD HOLE	312: GUIDE PROTRUSION
320: MAGNET	330: PIN

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-continued

[Reference Numerals]

400: STATOR	410: STATOR CORE
430: COIL	500: SHAFT
600: BUSBAR	700: SENSOR PART

The invention claimed is:

1. A motor comprising:

a shaft;
a rotor coupled to the shaft; and
a stator disposed outside the rotor,
wherein

the rotor includes a number (N) of rotor cores, and a plurality of magnets disposed on an outer circumferential surface of each of the rotor cores, at least 2N holes are formed in one of the N rotor cores, the at least 2N holes include a first group of at least N holes to arrange the rotor cores and a second group of least N holes to balance rotation of the rotor cores, and

first angles (θ_1) formed between adjacent pairs of the at least N holes of the first group are the same.

2. The motor of claim **1**, wherein a second angle (θ_2) formed by a first hole of the first group and one of the holes of the second group which is closest to the first hole is different from the first angle (θ_1) of the first group.

3. The motor of claim **2**, wherein the first hole of the first group is a reference hole for arranging the rotor cores.

4. The motor of claim **1**, wherein the holes of the first group and the holes of the second group are symmetrical based on a center of the rotor core.

5. The motor of claim **1**, wherein:

each of the N rotor cores includes a plurality of guide protrusions formed on an outer circumferential surface of the rotor core; and
the guide protrusions of the N rotor cores do not overlap in a vertical direction.

6. The motor of claim **1**, wherein:

each of the N rotor cores includes a first rotor core and a second rotor core, each of which includes a plurality of guide protrusions; and
the first angle is greater than a third angle (θ_3) formed by two guide protrusions, which are disposed adjacent to each other, of the plurality of guide protrusions formed on the first rotor core.

7. The motor of claim **6**, wherein the first angle (θ_1) is a sum of the third angle (θ_3) and an angle (θ_4) formed by one of the guide protrusions of the first rotor core and the guide protrusion, which is closest to the one of the guide protrusions, of the second rotor core.

8. A motor comprising:

a shaft;
a rotor coupled to the shaft; and
a stator disposed outside the rotor,
wherein

the rotor includes a first rotor core, a second rotor core, and a third rotor core, each of which includes M holes that are spaced apart from each other, the M holes include a first hole which is a reference hole, a second hole adjacent to the first hole, and a third hole adjacent to the second hole,

the first hole of the first rotor core is disposed to overlap the second hole of the second rotor core and the third hole of the third rotor core in a vertical direction, and the rotor further includes a pin positioned to pass through the first hole of the first rotor core, the

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second hole of the second rotor core, and the third hole of the third rotor core.

9. The motor of claim 8, wherein

each of the first rotor core and the second rotor core includes a plurality of guide protrusions, and

two holes, which are adjacent to each other, of the holes of the first rotor core form a first angle (θ_1) which is the same as a sum of an angle (θ_3) formed by two guide protrusions, which are adjacent to each other, of the guide protrusions of the first rotor core and an angle (θ_4) formed by the guide protrusion of the first rotor core and the guide protrusion, which is closest to the guide protrusion of the first rotor core in a circumferential direction, of the second rotor core around a center of the first rotor core.

10. The motor of claim 8, wherein:

the M holes include a pair of the first holes, a pair of the second holes, and a pair of the third holes,

the pair of first holes of the first rotor core are disposed to overlap the pair of second holes of the second rotor core and the pair of third holes of the third rotor core in a vertical direction, and

the rotor further includes a pair of the pins positioned to pass through, respectively, the pair of first holes of the first rotor core, the pair of second holes of the second rotor core, and the pair of third holes of the third rotor core.

11. A motor comprising:

a shaft;

a rotor coupled to the shaft; and

a stator disposed outside the rotor,

wherein

the rotor includes a plurality of rotor cores and a plurality of magnets disposed on an outer circumferential surface of each of the rotor cores,

each of the rotor cores includes first holes, second holes, and third holes,

two of the first holes, two of the second holes, and two of the third holes are disposed mutually opposite to each other based on a center (C) of the shaft,

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a first angle (θ_1) formed by one of the first holes and the second hole is the same as an angle formed by the second hole and the third hole around the center (C), the plurality of rotor cores include a first rotor core, a third rotor core, and a second rotor core disposed between the first rotor core and the third rotor core, and

the first hole of the first rotor core, the second hole of the second rotor core, and the third hole of the third rotor core overlap in a shaft direction.

12. The motor of claim 11, wherein, when the number of the magnets is six, a second angle (θ_2) formed by the one of the first holes and the third hole which is disposed adjacent to the one of the first holes around the center (C) is smaller than the first angle (θ_1).

13. The motor of claim 12, wherein the first angle (θ_1) is 66.67° .

14. The motor of claim 11, wherein, when the number of the magnets is eight, a second angle (θ_2) formed by the one of the first holes and the third hole which is disposed adjacent to the one of the first holes around the center (C) is greater than the first angle (θ_1).

15. The motor of claim 14, wherein the first angle θ_1 is 50° .

16. The motor of claim 11, wherein a sum of an angle formed by the first hole and the second hole, an angle formed by the second hole and the third hole, and the second angle θ_2 is 180° .

17. The motor of claim 11, wherein the first hole and the second hole are symmetrical based on a virtual line (L1) connecting a center of the third hole and a center (C) of the rotor core.

18. The motor of claim 11, wherein the rotor further includes a pin disposed to pass through the first hole of the first rotor core, the second hole of the second rotor core, and the third hole of the third rotor core which are disposed to overlap in a vertical direction.

19. The motor of claim 18, wherein the rotor includes two of the pins.

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